3.0 PROBLEM FORMULATION

The purpose of the problem formulation is to establish the exposure setting and ecological receptors used as the basis for the exposure assessment for the Phase I ERA. The main aspects of the problem formulation include (1) characterization of the exposure setting, (2) development of habitat-specific food webs, (3) identification of assessment endpoints, and (4) identification of measurement receptors.

3.1 CHARACTERIZATION OF THE EXPOSURE SETTING

The objective of the exposure setting characterization is to identify habitats, receptors, and other attributes that may be impacted by COPCs emitted from the treatment units at DCD. The characterization covers a 50-km radius; however, it focuses on the 20-km assessment area. The identification of habitats forms the basis for the categorization of plant and animal receptors into communities and feeding guilds that are used to develop food webs, as discussed in Section 3.2. In addition, the identification of receptors that are representative of the habitats provides the information necessary to formulate assessment endpoints (Section 3.3) and identify measurement receptors (Section 3.4).

3.1.1 Identification of Habitats

Land use–land cover maps, topographic maps, and National Wetland Inventory maps were obtained and evaluated to identify habitats out to 50 km from DCD (U.S. EPA 1999). The major habitats include a salt desert shrub valley (shrub-scrub ecosystem), sagebrush-grass benchland (montane ecosystem) east and west of DCD, and several small aquatic ecosystems. These major habitats are composed of a mosaic of subhabitats, including riparian, intermittent streams, salt shrub, cropland, alkali meadow, chaparral, and grasslands.

Figure 3-1 shows the locations of the shrub-scrub, montane, and aquatic habitats in the assessment area. The aquatic habitats that will be evaluated include Rush Lake, Atherly Reservoir (Fitzgerald Wildlife

FIGURE 3-1

Refuge), Clover Pond, and Rainbow Reservoir. The Phase I ERA will be based on the quantitative evaluation of locations within 20 km of DCD (see Figure 2-2).

3.1.2 Identification of Ecological Receptors

Available information about ecological receptors present or potentially present in the shrub-scrub, montane, and aquatic habitats in the assessment area was compiled, evaluated, and organized by habitat and food web. Threatened, endangered, and rare species that may occur in the assessment area were also identified. This receptor information was used to identify site-specific assessment endpoints and measurement receptors. The available receptor information is discussed below.

3.1.2.1 Summary of Habitat-Specific Receptors

The flora at DCD is a sagebrush community tending toward a desert shrub community on the valley floor (Foster & Wheeler, Inc. 1994). The lack of precipitation during the summer months limits plant life to several drought resistant and alkaline tolerant species (Tooele Army Depot 1995). The shrub-scrub vegetation generally consists of sagegbrush, rabbitbrush, and native grasses and forbs. The Integrated Natural Resource Management Plant (INRMP) for DCD (Tetra Tech 2000) summarized available information about animals that would be expected in the shrub-scrub habitat. MRI (1998) also presented a comprehensive list of plants and animals present or expected to be present in Rush Valley and the surrounding mountains. The MRI list of plants and animals was compiled from the "Utah Gap Analysis: An Environmental Information System" (MRI 1998). In addition, information from the Bureau of Land Management (BLM 2002), the U.S. Department of Agriculture Forest Service Fire Effects Information System (USDA FS 2002), and the Utah Division of Wildlife Resources (UDWR 2002).

Common plant associates in the shrub-scrub valley floor include big sagebrush (*Artemesia tridentate*), black sagebrush (*A. nova*), Douglas rabbitbrush (*Chrysothamnus douglasii*), plains prickly pear (*Opuntia polyacantha*), and green rabbitbrush (*C. viscidiflorus*). Grasses include bluebunch wheatgrass (*Agropyron spicatum*), Indian ricegrass (*Achantherum hymenoides*), and plains bluegrass (*Poa arida*).

Common mammals include the pronghorn antelope (*Antilocapra americana*), mule deer (*Odocoileus hemionus*), black-tailed jackrabbit (*Lepus californicus*), and rock squirrel (*Spermophilus variegates*). Common bird species include the Western grebe (*Aechmorphorus occidentalis*), red-tailed hawk (*Buteo jamaicensis*), sage grouse (*Centrocercus urophasianus*), and western snowy plover (*Charadrius alexandrius nivosus*). Resident and migratory raptor species observed on the installation during the

winter months include the red-tailed hawk, rough-legged hawk (*Buteo lagopus*), Swainson's hawk (*Buteo swainsoni*), golden eagle (*Aquila chrysaetos*), bald eagle (*Haliaeetus leucocephalus*), and the prairie falcon (*Falco mexicanus*) (MRI 1998). Also, a seasonal rookery for the great blue heron (*Ardea herodias*) has been observed on the south end of Rush Lake.

Common reptiles include the western fence lizard (*Scelporus occidentalis*), side-blotched lizard (*Uta stansburiana*), western yellow-bellied racer (*Coluber constrictor*), and great basin rattlesnake (*Crotalus viridis*). Common amphibians include the great basin spadefoot toad (*Scaphiopus intermentanus*), western woodhouse's toad (*Bufo woodhousei*), and northern leopard frog (*Rana pipiens*).

Common plant associates in the montane include pinyon (*Pinus edulis*), Utah juniper (*Juniperus osteosperma*), true mountain-mahogany (*Cercocarpus montanus*), Gambel oak (*Quercus gambelii*), Utah serviceberry (*Amelanchier utahensis*), big sagebrush, black sagebrush, budsage (*Artemesia spinescens*), spiny hopsage (*Grayia spinosa*), Gardner's saltbush (*A. gardneri*), green rabbitbrush, Hood's phylox (*Phylox hoodii*), and white sage (*Kochia americana*). Grasses include Indian ricegrass, bottlebrush squirreltail (*Elymus elymoides*), saline wildrye (*Leymus salinus*), and mutton grass (*Poa fendleriana*).

Common mammals in the montane include the pinyon mouse (*Peromyscus truei*), mule deer, and hoary bat (*Lasirius cinerus*). Birds expected in the montane include the bushtit (*Psaltrioparus minimus*), Golden eagle (*Aquila chrysaetos*), and western tanager (*Piranga ludoviciana*). Reptiles expected in the montane include the great basin rattlesnake, western terrestrial garter snake (*Thamnophis elegans*), and western fence lizard (*Sceloporus occidentalis*). Amphibians expected in the montane include the western woodhouse's toad and great basin spadefoot toad.

The INRMP (Tetra Tech 2000) reported that little information exists on fish and other aquatic species inhabiting aquatic environments in the assessment area. MRI (1998) reported that cattails, sedges, and other wetland vegetation are common to the surface water bodies. It is assumed that the water bodies would also support populations of phytoplankton, benthic macroinvertebrates, zooplankton, small fish, and piscivorous birds.

3.1.2.2 Listed Endangered, Threatened, and Candidate Species

No federal or state species listed as threatened or endangered are known to inhabit or potentially inhabit DCD property (Tetra Tech 2000). UDWR (2001) indicates three species occurring in Tooele County are federally listed as threatened or endangered, or are candidates for listing. These species include Ute Ladies'-Tresses (*Spiranthes diluvialis*) (threatened) and the American bald eagle (*Haliaeetus leucocephalus*) (threatened). In addition, the Yellow-billed Cuckoo (candidate) may possibly occur in

Tooele County. The State of Utah classification for sensitive species includes extinct, endangered, threatened, and species of special concern. State listed sensitive species that may occur in Tooele County include the American Peregrine falcon (*Falco peregrinus anatum*) and the Ferruginous hawk (*Buteo regalis*) (UDWR 1998). Numerous species have also been identified as species of special concern. The federal and state listed species are presented in Table 3-1.

3.1.3 Identification of Special Ecological Areas

A special ecological area is a habitat that could require special consideration in the risk assessment because (1) unique or rare ecological receptors and natural resources are present, or (2) the area has received special designation, such as a national monument (U.S. EPA 1999). Based on a review of available information, several special ecological areas within 50 km of DCD were identified. They include U.S. Forest Service land, State wildlife reserves (such as the Fitzgerald Wildlife Management Area), wilderness areas, and locations of occurrences and sightings of UDWR (2002) sensitive species (Figure 3-2). Sightings were reported for the following receptors:

- American white pelican
- American bald eagle
- Bonneville cutthroat trout
- California floater
- Caspian tern
- Desert valvata
- Ferruginous hawk
- Glossy valvata
- June sucker
- Least chub
- Long-billed curlew
- Lyrate mountainsnail
- Osprey
- Peregrine falcon
- Southern tightcoil
- Thickshell pondsnail
- Townsend's big-eared bat
- Utah Lake sculpin

TABLE 3-1

FEDERAL AND STATE LISTED SPECIES IN THE DCD VICINITY

Species	Federal Status [a]	State Status [b]
Mammals		
Brazilian free-tailed bat (*Tadardia brasiliensis*)		Sensitive
Merriam's shrew (*Sorex merriami*)		Rare
Preble's shrew (*Sorex preblei*)		Rare
Ringtail (*Bassariscus astutus*)		Sensitive
Townsend's big-eared bat (*Plecotus townsendii*)		Sensitive
Western red bat (*Lasiurus blossevillii*)		Sensitive
Western small-footed myotis (*Myotis ciliolabrum*)		Rare
Birds		
Bald eagle (*Haliaeetus leucocephalus)*	Threatened	Threatened
Bobolink (*Dolichonyx oryzivorus*)		Sensitive
Burrowing owl (*Athene cunicularia*)		Sensitive
Common yellowthroat (*Geothlypis trichas*)		Sensitive
Grasshopper sparrow (*Ammodramus savannarum*)		Sensitive
Lewis' woodpecker (*Melanerpes lewis*)		Sensitive
Long-billed curlew (*Numenius americanus*)		Sensitive
Peregrine falcon *(Falco peregrinus*)	Endangered	Endangered [c]
Sandhill crane (*Grus canadensis*)		Rare
Short-eared owl (*Asio flammeus*)		Sensitive
Swainson's hawk (*Buteo swainsoni*)		Sensitive
Reptiles		
Milk snake (*Lampropeltis triangulum*)		Sensitive
Amphibians		
Spotted frog (*Rana luteiventris*)	Conservation agreement species	Conservation agreement species [c]
Fish		
Least chub (*Iotichthys plegethontis*)	Proposed endangered	Conservation agreement species [c]
Invertebrates		
Southern Bonneville springsnail (*Pyrgulopsis transversa*)		Rare
Toquerville springsnail (*Pyrulopsis kolobensis*)		Rare
Plants		
Ute Ladies'-tresses (*Spiranthes diluvialis*)	Threatened	Rare [d]

Notes:

[a] Source: UDWR 2001

[b] Source: UDWR 1998, except where footnoted otherwise.

[c] This species has the protected state status that is indicated. UDWR (2001) did not list the species as occurring in Tooele County. However, the DCD INRMP (Tetra Tech 2000) reported information indicating that the species was observed near DCD.

[d] The State of Utah does not provide a protected status for plants. However, plants are categorized by the state based on the Natural Heritage Program system.

FIGURE 3-2

- Utah physa
- Ute ladies'-tresses
- Western toad

The species sighted within the 20-km assessment area include the ferruginous hawk, the American bald eagle, and Ute ladies'-tresses.

Rare plant species reported by UDWR (2002) within 50 km of DCD include:

- Alpine peppergrass
- Broadleaf penstemon
- Cottam's cinquefoil
- Coulter biscuitroot
- Pohl milkvetch
- Purple-eyed grass
- Sand cholla
- Ute ladies'-tresses

The species sighted within 20 km of DCD include broadleaf penstemon, pohl milkvetch, and Ute ladies'-tresses.

3.2 DEVELOPMENT OF FOOD WEBS

Receptor interactions (e.g., predator–prey) are evaluated to build food webs that are used to estimate indirect exposure by a measurement receptor to a COPC. Plants and animals were categorized according to their habitats and feeding niches, following the example food webs presented in U.S. EPA (1999). The food webs developed for the shrub-scrub, montane, and aquatic habitats are discussed below. The food webs have been organized to be consistent with the mathematical equations provided by U.S. EPA (1999).

For completeness, the descriptions of the food webs mention the amphibians and reptiles expected to be found in the assessment area. However, these receptors are not quantitatively evaluated in a combustion SLERA because information required to model exposure and assess toxicity for these animals is insufficient (U.S. EPA 1999).

3.2.1 Shrub-Scrub Food Web

The simple shrub-scrub food web (Figure 3-3) shows the communities and guilds in four trophic levels (TL). TL1 receptors are the primary producers and they include the grasses, forbs, and shrubs. TL2 includes detritivores (soil invertebrates), herbivorous mammals (such as pronghorn antelope, desert cottontail, and mule deer), and herbivorous birds (sage grouse, house finch, and chipping sparrow). TL3 includes the omnivorous mammals (such as deer mouse, canyon mouse, and striped skunk); herbivorous amphibians and reptiles (side-blotched lizard, northern leopard frog, and western woodhouse toad); and insectivorous birds (such as the American robin, barn swallow, and northern flicker). The TL4 or top predators include carnivorous mammals (such as the coyote and red fox), carnivorous birds (hawks, falcons, and owls), and carnivorous reptiles (rattlesnake and lizards).

3.2.2 Montane Food Web

The simple montane food web (Figure 3-4) also shows the communities and guilds in four TLs. It has been organized to be consistent with the mathematical equations provided by U.S. EPA (1999). TL1 receptors are the primary producers and they include forbs, grasses, shrubs, and trees. TL2 includes detritivores (soil invertebrates), herbivorous mammals (such as elk and rodents), and herbivorous birds (blue grouse, sage thrasher, and lark sparrow). TL3 include the omnivorous mammals (such as deer mouse and antelope squirrel), herbivorous amphibians and reptiles (toads and lizards), and insectivorous birds (such as the chukar, canyon wren, and northern flicker). The TL4 or top predators include carnivorous mammals (such as the coyote and bobcat), carnivorous birds (hawks and eagles), and carnivorous reptiles (snakes and lizards).

3.2.3 Aquatic Food Web

The generic aquatic food web developed for the Phase I ERA will be used to evaluate Rush Lake, Atherly Reservoir (Fitzgerald Wildlife Management Area), and the BLM ponds (Clover Pond). Rainbow Reservoir will be evaluated using a simple food chain model composed of benthic invertebrates, trout, and a piscivorous bird (Tetra Tech 2002b). The increased number of aquatic communities makes the generic aquatic food web in Figure 3-5 more complex than the food webs for the upland habitats. Note that the aquatic communities (algae, zooplankton, herbivorous/planktivorous fish, and carnivorous fish) are evaluated as the single “aquatic life” (highlighted in green). However, to assess indirect exposure by

FIGURE 3-3

Figure 3-4

Figure 3-5

mammals and birds that consume aquatic organisms, exposure by each aquatic community is modeled separately (See Section 4). In addition to the aquatic communities, the aquatic food web includes two major sediment communities—rooted plants and benthic macroinvertebrates. In addition to herbivorous/planktivorous fish, other TL2 receptors include herbivorous birds that feed on rooted aquatic plants. TL3 and TL4 are modeled similar to the upper trophic levels of the upland food webs.

3.3 IDENTIFICATION OF ASSESSMENT ENDPOINTS

A U.S. EPA combustion SLERA uses assessment endpoints to characterize potential ecological risk. Assessment endpoints are explicit expressions of the actual ecological attributes or resources that are to be protected (U.S. EPA 1999). Therefore, their selection represents a scientific and management decision point. An assessment endpoint includes a receptor and one or more attributes relevant to ecosystem structure and function. Tables 3-2 through 3-4 present the assessment endpoints for the shrub-scrub, montane, and aquatic food webs evaluated in the Phase I ERA.

3.4 IDENTIFICATION OF MEASURES OF EXPOSURE

Measures of exposure include those aspects that estimate the level of exposure of an assessment endpoint to a COPC. For a combustion SLERA, measures of exposure specifically include the identification of exposure scenario locations and measurement receptors for each habitat-specific food web. Exposure scenario locations are selected to determine estimated exposure levels (see Section 4.0). Measurement receptors are selected as the means to quantify the measures of effect, which are used to evaluate the response of, and potential changes in, the assessment endpoint when exposed to a COPC. To determine potential effects, a measurement receptor must be selected for each community and guild targeted for quantitative evaluation. The selection of exposure scenario locations and measurement receptors for each food web evaluated in the Phase I ERA are discussed below.

3.4.1 Identification of Exposure Scenario Locations

Exposure scenario locations are one or more habitat-specific air dispersion modeling grid nodes for which unitized air concentrations and deposition rates have been determined.

TABLE 3-2

ASSESSMENT ENDPOINTS FOR COMMUNITIES AND GUILDS IN SHRUB-SCRUB FOOD WEB

Community or Guild	Representative Receptors	Critical Attribute
Terrestrial Plants	Grasses, forbs, shrubs	Photosynthetic conversion of light energy into biomass; food source for herbivores and omnivores; critical habitat for small mammals and granivorous bird populations
Soil Invertebrates	Beetles, spiders	Important in detritus processing; important food source for insectivorous birds
Herbivorous Mammals	Pronghorn antelope, mule deer, desert cottontail	Convert plant biomass into animal tissue; important for seed dispersal; prey item for carnivorous mammals
Herbivorous Birds	Sage grouse, finch	Prey for raptors; important in seed dispersal; convert plant biomass into animal tissue
Omnivorous Mammals	Deer mouse	Prey for carnivores
Insectivorous Birds	American robin	Prey for raptors
Carnivorous Mammals	Coyote	Large carnivorous mammals regulate prey populations
Carnivorous Birds	Red-tailed hawk	Raptors and other carnivorous birds regulate prey populations

TABLE 3-3

ASSESSMENT ENDPOINTS FOR COMMUNITIES AND GUILDS IN MONTANE FOOD WEB

Community or Guild	Representative Receptors	Critical Attribute
Terrestrial Plants	Grasses, forbs, shrubs, trees	Photosynthetic conversion of light energy into biomass; food source for herbivores and omnivores; critical habitat for small mammals and granivorous bird populations
Soil Invertebrates	Beetles, spiders	Important in detritus processing; important food source for insectivorous birds
Herbivorous Mammals	Elk, pinyon mouse	Convert plant biomass into animal tissue; important in seed dispersal; prey item for carnivorous mammals
Herbivorous Birds	Blue grouse, sage thrasher	Convert plant biomass into animal tissue; prey for raptors; important in seed dispersal
Omnivorous Mammals	Deer mouse	Prey for carnivores
Insectivorous Birds	Chukar, canyon wren	Prey for raptors
Carnivorous Mammals	Coyote	Large carnivorous mammals regulate prey populations
Carnivorous Birds	Red-tailed hawk	Raptors and other carnivorous birds regulate prey populations

TABLE 3-4

ASSESSMENT ENDPOINTS FOR COMMUNITIES AND GUILDS IN AQUATIC FOOD WEB

Community or Guild	Representative Receptor	Critical Attribute
Aquatic Plants	Rooted vascular plants, algae	Photosynthetic conversion of light energy into biomass; food source for herbivores and planktivores; critical habitat and bottom stability (rooted plants)
Benthic Invertebrates	Insect larvae, crayfish	Important in detritus processing; main food source for juvenile fish
Zooplankton	Copepods, cladocera	Important food source for planktivorous fish
Planktivorous/Herbivorous Small Fish	Sunfish, mosquitofish	Comprise majority of tissue biomass in aquatic ecosystems. Regulate algae and zooplankton; important food item for carnivorous fish and piscivorous birds
Herbivorous Birds	Northern pintail	Prey for raptors; important in seed dispersal
Omnivorous Mammals	Common muskrat	Prey for carnivorous birds and mammals; important in seed dispersal; regulate biomass of aquatic vegetation
Omnivorous Aquatic Birds	Mallard	Prey for carnivorous birds and mammals; important in seed dispersal; regulate biomass of aquatic vegetation and benthic invertebrates
Insectivorous Birds	American robin	Prey for raptors; important for energy transfer
Carnivorous Fish	Largemouth bass	Regulate fish populations
Carnivorous Mammals	Coyote	Large carnivorous mammals regulate prey populations
Carnivorous Birds	Red-tailed hawk	Raptors and other carnivorous birds regulate prey populations
Piscivorous Birds	Great blue heron	Regulate prey populations

The air concentrations and deposition rates are multiplied by COPC-specific emission rates to determine COPC-specific media concentrations that are used to calculate exposure levels (See Section 4.0). Exposure scenario locations will be identified using the EcoRisk View software (Lakes Environmental 2001). During the development of the EPA (1999) guidance for combustion facilities, Tetra Tech validated the accuracy of the software by comparing software output to hand calculations.

Exposure scenario locations for each habitat will be determined for each source at TOCDF and CAMDS. U.S. EPA (1999) recommends that the highest 1-year annual average COPC concentration in soil be used as the soil concentration for estimating ecological risk, which would typically occur at the end of the time period of combustion. For the receptors in the shrub-scrub and montane habitats, the highest 1-year annual average air concentration and wet and dry deposition rates (of the five yearly averages), specific to each habitat, will be used to calculate an average soil concentration for each upland habitat (Tetra Tech 2002c).

Surface water and sediment concentrations of COPCs specific to each of the four water bodies will be determined according to the procedures presented in U.S. EPA (1999). Watershed areas will be defined from topographic maps, and the highest 1-year annual average unitized air concentrations and deposition rates (of the five yearly averages) will be used to calculate the COPC concentration in watershed soil for estimating water body loading. The unitized deposition rates for grid nodes over the area of the water body will be used to determine the COPC concentration in surface water resulting from direct deposition. The COPC concentration in watershed soil and the COPC concentration in surface water resulting from direct deposition will be used to calculate the total and dissolved COPC concentrations in surface water and the COPC concentration in bed sediment. These concentrations will be used in the aquatic food web exposure assessment for each water body.

3.4.2 Measurement Receptors for Soil, Surface Water, and Sediment Receptors

In accordance with U.S. EPA (1999) recommendations, communities or assemblages of communities have been selected as the measurement receptors for receptors inhabiting soils, surface waters, and sediments in the assessment area, as follow:

- Soil—Soil invertebrate community and terrestrial plant community

- Surface water—Algae, zooplankton, and fish communities
- Sediment—Benthic invertebrate community

Note that the surface water communities are evaluated together as "aquatic life," which corresponds with the basis for the toxicity reference values (TRV) (see Section 5.0).

3.4.3 Measurement Receptors for Mammal and Bird Feeding Guilds

A measurement receptor was selected for each guild to (1) model a COPC dose ingested to mammals and birds and (2) model whole body COPC concentrations in mammal and bird prey ingested by mammalian and avian measurement receptors. The selected measurement receptors ensure that potential risk to other receptors in each guild is not underestimated. The following factors (U.S. EPA 1999) were evaluated to identify a measurement receptor:

- **Ecological Relevance**. Ecologically relevant attributes fall under the categories of food, habitat, production, seed dispersal, pollination, and decomposition. Critical attributes include those that affect or determine the function or survival of a population.
- **Exposure Potential**. Receptors with high exposure potentials are those that, due to their metabolism, feeding habits, location, or reproductive strategy, tend to have higher potentials for exposure than other receptors. For example, the metabolic rates of small receptors are generally higher than those for large animals. This results in a higher ingestion per body weight (i.e., increased exposure potential).
- **Social or Economic Importance**. An assessment endpoint may also be based on socially or economically important receptors. These types of receptors include species valued for economic importance such as game. For these receptors, critical attributes include those that affect survival, production, and fecundity characteristics.
- **Availability of Natural History Information**. Natural history information is essential to quantitatively evaluating risk to measurement receptors. If this information, which includes body weight and food, water, soil, and sediment ingestion rates, is unavailable for the desired measurement receptor, natural history information for a surrogate species was used.

U.S. EPA (1999) also recommends considering receptor sensitivity to a COPC when identifying measurement receptors. However, use of the U.S. EPA-recommended TRVs (Section 5.0), which represent the toxicity values available for the most sensitive endpoint for the most sensitive receptor, ensures that sensitive receptors are evaluated.

3.4.3.1 Measurement Receptors for Shrub-Scrub Food Web

The following sections present the measurement receptors selected for mammal and bird guilds in the shrub-scrub food web that will be quantitatively evaluated in the Phase I ERA. The determination of food and media ingestion rates used to calculate COPC intake is also discussed.

Herbivorous Mammals

The pronghorn antelope (*Antilocarpa americana*) was chosen as the receptor for this guild because of its economic importance in Utah as a game species. Pronghorn are endemic to North America and are the only native North American ungulate possessing scientific nomenclature for a single family, genus, and species (Yoakum 1980). It has been estimated that in 1804, when Lewis and Clark explored the North American continent, there were 40 million antelope roaming the plains of western North America (Yoakum 1980; American Museum of Natural History [AMNH] 2000; Nebraska Game and Parks Commission [NGPC] 2000). By the beginning of the 1900s, the population had been decimated by the exploitation of natural resources to somewhere between 10,000 and 20,000 animals (Yoakum 1980; AMNH 2000; NGPC 2000). The antelope has made an impressive return, and today it is estimated that there are approximately 1 million pronghorn living in North America (AMNH 2000; NGPC, 2000). Their range is from the central United States (North Dakota to Texas) west to California and from Alberta and Saskatchewan, Canada, south to portions of northwestern Mexico (Yoakum 1980; Forest Effects Information System [FEIS] 1996).

Pronghorn antelope prefer browse and forbs as food items (Hoover 1966). Sagebrush, a dominant plant species in Rush Valley, is a commonly selected food item (Bayless 1969). Antelope herds generally occupy ranges of 5 to 10 miles and have populations that may reach up to 200 animals in winter months (Yoakum 1980). Coyote, bobcat, mountain lions, and golden eagles are important predators of the pronghorn antelope, with the bobcat, coyote, and golden eagle feeding mainly on fawns, especially newborns (Yoakum 1980; Goodwin 1976; FEIS 1996; Reichel 1991; Ockenfels 1994).

Herbivorous Birds

The sage grouse (*Centrocercus urophasianus*) was selected as the measurement receptor for the herbivorous bird guild. This bird was chosen because of its declining numbers and its presence in the area, including the use of the habitat for brooding. The decline of the sage grouse is primarily because of sagebrush destruction for agricultural purposes (Wallestad 1975). The range of the sage grouse includes Colorado, Utah, Wyoming, Montana, Idaho, California, Oregon, and a portion of South Dakota (Gough and others 1998). The sage grouse is on the Audubon Society's Utah Watch List as a high priority species (Muehter 1998). A sage grouse conservation plan is also currently being developed by the State of Utah (Mitchell and Maxfield 2000). There are, however, portions of Utah where sage grouse hunting is allowed. For an area to be eligible for sage grouse hunting, there must be a 3-year running average of at least 500 breeding birds (Mitchell and Maxfield 2000). There are four areas that met the criteria in 1999: western Box Elder County, all of Rich County in northern Utah, Blue and Diamond Mountains in northeastern Utah, and Parker Mountain in south-central Utah (Mitchell and Maxfield 2000). The estimated sage grouse breeding population for Tooele County in the year 2000 was 411 individuals based on strutting ground counts (Mitchell and Maxfield 2000).

Wallestad (1975) reported that sagebrush domination of the vegetation was important for all areas of the life history of the sage grouse. He found that 62 percent of the total food volume of 299 sage grouse crop samples was sagebrush. According to UDWR, most of Rush Valley is sage grouse brooding habitat. This is supported by the fact that the dominant plant occurring in Rush Valley is sagebrush. Coyote, badger, bobcat, and numerous raptors prey upon sage grouse (Kindschy 1986; Bailey 1981; Pennycuick and others 1994; Dunkle 1977).

Omnivorous Mammals

The deer mouse (*Peromyscus maniculatus*) was selected as the measurement receptor for the omnivorous mammal guild. This species was chosen because of its large numbers and its importance in energy and contaminant transfer to predators. The food ingestion rate of the deer mouse is higher than that of other omnivorous mammals identified for the shrub-scrub food web; therefore, potential risks to the other receptors can be inferred from results based on the deer mouse. The majority of the deer mouse diet is composed of arthropods and seeds (FEIS 1996). Deer mouse occupy virtually any terrestrial habitat with a population density of approximately 19 individuals per square km (Maser and others 1981;

U.S. EPA 1993). They are an important prey species for most predators, including snakes, owls, mink, marten and other weasels, skunks, bobcat, domestic cats, coyote, foxes, and ringtail (Maser and others 1981).

Insectivorous Birds

The American robin (*Turdus migratorius*) was selected as the measurement receptor for the insectivorous bird guild. The American robin is a very common bird in North America and will occupy almost any habitat type as long as there is open ground for foraging and access to fresh water (Canadian Wildlife Survey [CWS] 2000). Feeding areas for the American robin can reach a size of up to a 20-km radius from the bird's roost in winter (U.S. EPA 1993). Robins feed by hopping along the ground looking for invertebrates (which comprise approximately 40 percent of the diet) or searching shrubs and low tree branches for berries and insects (U.S. EPA 1993; CWS 2000). The robin's population density is the highest in the spring when there are approximately 198 pairs of birds per square km (U.S. EPA 1993). The main predators for the robin include raptors and bobcats (CWS 2000).

Carnivorous Mammals

The coyote (*Canis latrans*) was selected as the measurement receptor for the carnivorous mammal guild. It was chosen because it is very common in the West, and has the potential to be exposed to COPCs through the food web because of its variable diet. Coyotes will occur in any habitat from grassland to boreal forest as long as there is a healthy population of available prey, and their home range can extend from 20 to 31 square km (NGPC 2000). Although its primary prey item is small mammals, coyotes are opportunistic and will eat almost any food item that they find, including fruits and berries (Bekhoff 1977). The coyote was also chosen because it will sometimes hunt with other coyotes and kill young and adult large mammals such as white-tailed deer and elk, especially in winter (Gese and Groth 1995; NGPC 2000). For example, Gese and Groth (1995) witnessed as few as two coyotes kill and consume an adult elk. Coyote population densities have been reported to be as high as two individuals per square km (NGPC 2000). Great horned owls, bald and golden eagles, bears, and wolves have been known to prey upon coyotes (ADF&G 2000).

Carnivorous Birds

The red-tailed hawk (*Buteo jamaicensis*) was selected as the measurement receptor for the carnivorous bird guild. This bird was chosen because it is a common and possible yearlong resident of the area. Red-tailed hawks will reside in a variety of habitats provided that there is accessible open area for hunting and forested areas for nesting (Oakland Zoo 2000). Their range includes virtually all of North America (Gough and others 1998). Their variable diet leaves them susceptible to contaminant ingestion through the food web. Although they feed mostly on small mammals, they will also eat birds, reptiles, and some insects (FEIS 1996; DeGraaf and others 1991; Dubois and others 1987; Palmer 1988). The population density of the red-tailed hawk rarely exceeds three pairs per square km and is usually less than 0.5 pair per square km (U.S. EPA 1993). Possible predators include other raptors, coyotes, bobcats, crows, and skunks (FEIS 1996).

3.4.3.2 Measurement Receptors for Montane Food Web

The measurement receptors selected for mammal and bird guilds in the montane food web are discussed below.

Herbivorous Mammals

The elk (*Cervus elaphus*) was selected as the measurement receptor for herbivorous mammals in the montane area because (1) it is socially important as a big game species in Utah, (2) it is close to DCD, and (3) it is a dominant large mammal. Elk have historically occupied a range in North America throughout most of the western states from Canada to Mexico (Bryant and Maser 1982). UDWR indicates that elk have summer and wintering grounds, along with calving grounds, in the Oquirrh Mountains east of DCD. The information also indicates a small summer range of elk in the hilltops approximately 45 km south-southeast of DCD. Elk spend the winter months in the lower elevations of mountains where the temperature is warmer and food is more readily available. They spend the summer months in the higher, cooler elevations where there is less competition for food, and suitable cover for calving.

Elk typically exhibit a browsing feeding strategy. This enables them to seek out food in large areas of land throughout the day. This may potentially put them in contact more often with contaminated food items and soil. Elk will begin feeding in the morning and continue for two or three hours (Skovlin 1982).

After ruminating for most of the late morning and early afternoon, elk will again feed for two or three hours before sunset (Skovlin 1982).

Adult and young elk may fall victim to predation. Usually young, old, or weak individuals are targeted by predators. However, healthy adults may also be taken by packs of wolves and coyotes. Young and weak elk may also fall victim to predators such as large raptors, wolves, coyotes, and mountain lions.

Herbivorous Birds

The blue grouse (*Dendragapus obscurus*) was chosen as the guild receptor for herbivorous birds due to its close proximity to the facility and its importance as a game bird species. The blue grouse inhabits high mountain terrain usually above 8,500 feet (Western Gamebird Alliance [WGA] 2000). They are usually found in stands of aspen, fir, or spruce in the winter months and in deciduous forests during the summer months (Robbins and others 1983). In the blue grouses' range near DCD, they most likely inhabit stands of Utah juniper with an understory of brush. Within 50 km of TOCDF, the blue grouse occurs in the Oquirrh Mountains east of the facility, the Stansbury Mountains west of the facility, and in the Sheeprock Mountains to the south-southwest (UDWR 2000a).

The diet of the blue grouse varies with the season. Grouse generally browse for their food among the forested stands that they inhabit. In winter, conifer needles and buds comprise up to 95 percent of the blue grouse diet (UDWR 2000a). These are readily available and abundant for consumption throughout the winter months. In summer, the diet includes green vegetation, seeds, buds, berries and insects (UDWR 2000a).

Blue grouse may fall victim to several different predators. In the state of Utah, and within the range of this study, predators of the blue grouse may include bobcat, mountain lion, coyote, red fox, and raptors. The predation of blue grouse may be limited by the high elevations they inhabit. Another limiting factor may be the dense understory habitat they prefer to inhabit. This preferred habitat provides much needed cover from predators and from the cold.

Omnivorous Mammals

The deer mouse was selected as the measurement receptor for the omnivorous mammal guild in the montane food web. The basis for its selection and the relevant natural history information is described above for the omnivorous mammals in the shrub-scrub food web.

Omnivorous Birds

The chukar (*Alectoris chukar*) was chosed as the receptor for the montane omnivorous bird guild because of its site-specific importance as a game species and importance to montane ecology. Chukars prefer steep, rocky, semi-arid slopes, and information indicates that the majority of the montane habitat within the study area is considered chukar habitat (UDWR 2000b). Although adults eat mostly vegetation, young chukar feed on a high proportion of insects, which is where the exposure of this guild would occur (FEIS 1996). Adult chukar also feed on numerous insects during the summer months and rely heavily on new growth cheat grass in the winter (UDWR 2000b). Predators of the chukar could include coyote, bobcat, foxes, skunks, badger, raccoon, mountain lion, coati, snakes, and many raptors (Bohl 1957).

Carnivorous Mammals

The coyote was selected as the measurement receptor for the carnivorous mammal guild in the montane food web. The basis for its selection and the relevant natural history information is described above for the carnivorous mammals in the shrub-scrub food web.

Carnivorous Birds

The red-tailed hawk was selected as the measurement receptor for the carnivorous bird guild in the montane food web. The basis for its selection and the relevant natural history information is described above for the carnivorous bird guild in the shrub-scrub food web.

3.4.3.3 Measurement Receptors for Aquatic Food Web

The measurement receptors selected for mammal and bird guilds in the montane food web are discussed below.

Herbivorous Birds

The northern pintail (*Anas acuta*) was chosen as the measurement receptor for the herbivorous bird guild because (1) waterfowl molting areas are located within the study area, (2) it is ecologically important as a prey item, and (3) it is socially important as a game species. Pintails are surface feeders of mostly aquatic vegetation (Bellrose 1980). Pintails are preyed upon by numerous predators, including skunks, magpies, gulls, ground squirrels, coyotes, foxes, raccoons, and badgers (Bellrose 1980). Although no information was available, it is reasonable to assume that raptors will also prey on pintails.

Omnivorous Mammals

The common muskrat (*Ondatra zibethicus*) was selected as the measurement receptor for the omnivorous mammal guild because it is an important link between the movement of contaminants in aquatic vegetation to predators in the ecosystem, and because it is known to inhabit the study area. In terms of social importance, muskrat is also sought after as a furbearing mammal. The fur is used for everything from purses and hats to fur for teddy bears (Van Eseltine 2000). Muskrats prefer habitat with dense emergent aquatic vegetation that is surrounded by herbaceous terrestrial vegetation (FEIS 1996). Although they feed mostly on vegetation, they will occasionally feed on frogs, crustaceans, dead birds, and fish (Perry 1982). Coyotes, raptors, bobcats, and snakes are all predators of the muskrat. The muskrat's maximum breeding density is five pairs per hectare (Perry 1982).

Omnivorous Aquatic Birds

The mallard duck (*Anas platyrhynchos*) was selected as the measurement receptor for the omnivorous aquatic bird guild because of its importance as a game species and its relative abundance in the area. In addition, waterfowl molting areas are located within the study area. The mallard is one of the most common and abundant species of duck in North America. Its range extends from Alaska south to Central America. Mallard ducks inhabit almost anywhere there is water. They can be found in most any pond, lake, river, stream, or marsh that has cover for nesting and ample food. Range maps indicate that the mallard has breeding and wintering ranges in Utah (Palmer 1976).

Mallard ducks are surface-feeders that tip into the water and use their bills to filter their food. Although mallards are mainly vegetarian (TPW 2000), feeding mostly on aquatic vegetation, seeds, grains and

stems, they may also consume fish eggs, mollusks, and other invertebrates from the water. The mallards diet will vary with season and local food abundance and availability.

Predators may be a factor that influence mallard duck numbers. Because of the mallard's abundance, they may be used as a staple food source for many predators. Within the study area around TOCDF, coyotes, bobcats, or raptors may prey upon the mallard.

Carnivorous Mammals

The coyote was selected as the measurement receptor for the carnivorous mammal guild in the montane food web. The basis for its selection and the relevant natural history information is described above for the carnivorous mammals in the shrub-scrub food web.

Carnivorous Birds

The red-tailed hawk was selected as the measurement receptor for the carnivorous bird guild in the montane food web. The basis for its selection and the relevant natural history information is described above for the carnivorous bird guild in the shrub-scrub food web.

Piscivorous Birds

The great blue heron (*Ardea herodias*) was selected as the measurement receptor because it is abundant in the area and, because it is a large bird, it will feed heavily in the water it occupies. This large feeding strategy will potentially put the bird in contact with a higher percentage of contaminants. Another reason it was chosen is that the great blue heron is a colonial bird. Therefore, any contamination may affect large numbers of birds, rather than an individual.

Great blue herons range across the United States into southern Canada and northern Mexico. They can be found in most any wet area in the United States aside from a few desert areas and high mountaintops. In Utah, great blue herons are listed as a common summer breeding resident, nesting in scattered colonies in lowland wetland areas and streams statewide (UDWR 2000c). The great blue heron prefers shallow marshes where fish are plentiful (U.S. EPA 1993), but will inhabit any low-lying area with sufficient water to maintain prey items.

The great blue heron's diet consists primarily of fish, which it grabs with its long beak while standing in shallow water. Although fish are its preferred prey item, the great blue heron will also eat amphibians, reptiles, crustaceans, insects, small birds, and mammals (Alexander 1977). Great blue herons mainly use two techniques when fishing: standing or slow wading (Willard 1977). The first involves standing still and waiting for a fish to swim within striking distance. The second is used to catch more sedentary prey as the heron will kick up these prey items.

Adult great blue herons have few natural predators due to their large size. However, extensive damage is done to eggs and nestlings by raptors and raccoons (INRIN 2000). In Utah, snakes, coyotes and other egg-eating predators may also prey upon the great blue heron.